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IS 12555 (1988): Signal conditioning devices for process control systems [ETD 18: Industrial Process Measurement and Control]

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Indian Standard

GUIDE FOR SIGNAL CONDITIONING DEVICES FOR PROCESS CONTROL SYSTEMS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

GUIDE FOR SIGNAL CONDITIONING DEVICES FOR PROCESS CONTROL SYSTEMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Bureau of Indian Standards on 27 October 1988, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 In industrial process control, process variables are converted into analogue or digital signals. A large number of automation applications place exacting demands on the signal processing. Process plans employ mainly standardized analogue signal which may be either a direct current or a dc voltage. In addition, binary direct voltage signals are used. As such signal conditioning devices have important roles in process signal transmission.

0.3 This standard serves as a guide for manufacturers and users of process signal conditioning device. This should be read with IS : 7728-1984* and IS : 8493-1977†.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960‡. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Specification for analogue dc current signals for process control systems (*first revision*).

†Specification for analogue dc voltage signals for industrial process measurement and control systems.

‡Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard applies to electrical signal conditioning devices, both analogue and digital, used in process control systems, used to condition, transmit, indicate and/or record, control or store information between the elements of same or different system(s).

1.2 This standard does not cover the external accessories associated with signal conditioning modules that may be necessary for process control systems.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Measuring Instruments

2.1.1 *Measuring Instrument* — A device intended to make a measurement alone, or in conjunction with other equipment.

2.1.2 *Measuring Transducer* — A measuring device which provides an output quantity having a given relationship to the input quantity.

Examples: a) Thermocouple, and

b) Current transformer.

2.1.3 *Measuring Chain* — A series of elements of a measuring instrument or system which constitutes the path of measurements signal from the input to the output.

2.1.4 *Measuring System* — A complete set of measuring instruments and other equipment assembled to carry out a specified measurement task.

NOTE — The term measuring installation is reserved for measuring apparatus, usually of the larger kind, which is permanently installed, for example, proverloop for flow measurement.

2.1.5 *Indicating (Measuring) Instrument* — A measuring instrument which displays the value of a measured or a related value.

2.1.6 *Recording (Measuring) Instrument* — A measuring instrument which provides a record (permanent or semi-permanent) of the value of a measured or a related value.

2.1.7 *Totalizing (Measuring) Instrument* — A measuring instrument which determines the value of a measurand by summation of the partial values of the measurand obtained simultaneously or consecutively from one or more sources.

2.1.8 *Integrating (Measuring) Instrument* — A measuring instrument which determines the value of a measurand by integrating a quantity with respect to another quantity.

2.1.9 *Analogue Measuring Instrument* — A measuring instrument in which the output or display is a continuous function of the value of the measurand.

NOTE — This term relates to the form of presentation of output or display, and not the principle of operation of the instrument.

2.1.10 *Digital Measuring Instrument* — A measuring instrument which provides a digitized output and/or display.

2.1.11 *Indicating Device* — For a measuring instrument, the set of components which displays the value of a measurand or a related value.

NOTE — An analogue indicating device provides an analogue indication and a digital indicating device provides a digital indication.

2.1.12 *Recording Device* — For a recording instrument, the set of components which records the value of a measurand or a related value.

2.1.13 *Recording Medium* — A strip, disc, sheet or other structure on which is recorded, the value of a measurand or a related value.

NOTE 1 — A recording medium bearing pre-printed coordinate lines is generally called a recording chart.

NOTE 2 — An electronic or magnetic recording medium may be called a memory.

2.1.14 *Sensor* — The element of a measuring instrument or measuring chain to which a measurand is directly applied.

Examples : a) Thermocouple of a thermoelectric thermometer,

b) Rotor of a turbine flow meter, and

c) Float of a level measuring instrument.

2.1.15 *Detector* — A device or substance which indicates the presence of a particular quantity without necessarily providing its value.

NOTE — In some cases, an indication may be produced only when the value of the quantity reaches a given threshold.

Example : Halgen leak detector.

2.1.16 *Scale Mark* — A line or other mark on an indicating device corresponding to one or more defined values of a measurand.

NOTE — For digital and semi-digital indications, the numbers themselves are equivalent to scale marks.

2.1.17 *Index* — The fixed or movable part of an indicating device whose position with reference to the scale marks enables an indicated value to be determined.

Examples : a) Pointer,

b) Luminous spot,

c) Liquid surface, and

d) Recording pen.

2.1.18 *Scale Length* — For a given scale, the length of the line between the first and the last scale marks and passing through the centres of all the shortest scale marks.

NOTE 1 — The line may be real or imaginary, straight or curved.

NOTE 2 — Scale length is expressed in units of length regardless of the units of the measurand or the units marked on the scale.

2.1.19 *Scale Range* — For a given scale, the range of scale values between the extreme scale marks.

NOTE — The scale range is expressed to the units marked on the scale, regardless of the units of the measurand, and is normally stated in term of its lower and upper limits, for example, 0 to 16 bar.

2.1.20 *Scale Division* — The part of a scale between any two successive scale marks.

2.1.21 *Scale Spacing* — The distance between any two successive scale marks measured along the same line as the scale length.

NOTE — Scale spacing is expressed in units of length regardless of the units of the measurand or the units marked on the scale.

2.1.22 *Scale Interval* — The difference between the scale values corresponding to two successive scale marks.

NOTE — Scale interval is expressed in the units marked on the scale regardless of the units of the measurand.

2.1.23 *Linear Scale* — A scale in which each scale spacing is related to the corresponding scale interval by a coefficient of proportionality which is constant throughout the scale.

NOTE — A linear scale having constant scale intervals is called a regular scale.

2.1.24 *Non-linear Scale* — A scale in which each scale spacing is related to the corresponding scale interval by a coefficient of proportionality which is not constant throughout the scale.

NOTE — Some non-linear scales are given special names, such as, square-law scale, logarithmic scale, etc.

2.1.25 *Suppressed-Zero Scale* — A scale in which part of the scale range occupies a disproportionately small part of the scale length.

2.1.26 *Expanded Scale* — A scale in which part of the scale range occupies a disproportionately large part of the scale length.

2.1.27 *Dial* — The part of an indicating device, fixed or moving, which carries the scales.

NOTE — In some indicating devices, the dial takes the form of drums or discs bearing numbers and moving relative to a fixed index or window.

2.1.28 *Scale Numbering* — The set of numbers marked on a scale which either correspond to the value of the measurand defined by the scale marks or merely indicate the numeric order of the scale marks.

2.1.29 *Zero of a Measuring Instrument* — The direct indication of a measuring instrument when the instrument is in use with zero value of the measured, any auxiliary power supply required to operate the instrument being switched on.

NOTE 1 — The term 'mechanical zero' is often used when the instrument is not in use and any auxiliary power supply is switched off.

NOTE 2 — The term is called 'electrical zero' in the case of a measuring instrument having an electrical auxiliary power supply.

NOTE 3 — The mechanical zero may not coincide with the electrical zero, and in some type of instrument the mechanical zero may be indeterminate.

2.1.30 *Calibration* — The operation of fixing the positions of the gauge marks or scale marks of a measuring instrument in relation to the corresponding values of the measurand.

2.1.31 *Adjustment* — The operation intended to bring a measuring instrument into a state of performance and freedom from bias suitable for its use.

2.1.32 *Power Supply* — This unit enables a system to generate one of the recommended dc current or voltage signals by supplying the necessary and required dc power.

2.1.33 *Signal Connections and Signal Common* — Signal circuits in the process control system may have common electrical connections. One of these may or may not be connected to ground and is defined as the signal common.

2.1.34 *Signal Isolation Units* — The input and output signals are galvanically isolated. There is no electrical connection between signal loop and all other circuits including ground.

2.1.35 *Signal Transmitter* — A transducer which responds to a measured variable by means of a sensing element and converts it into a standardized transmission signal which is a function of the measured variable.

2.1.36 *Signal Computer* — A device used to perform some mathematical operations like addition, subtraction, multiplication, division, square root extraction, etc, deriving inputs from the signal parameter.

2.1.37 *Precision Integrator* — This device gives a pulse-rate output which is linearly proportional to the input signal amplified to drive an electromagnetic or an electronic counter, to give a reading or quantity.

2.1.38 *Controller* — A device which operates automatically to regulate a controlled variable. These may be of different types such as on-off derivative integral, proportional, proportional plus derivative, proportional plus integral or proportional plus integral plus derivative.

2.1.39 *Signal Convertor* — A transducer which converts one standardized transmission signal to another.

2.1.40 *Signal Amplifier* — A device that enables an input signal to control power from a source independent of the signal and thus be capable of delivering an output that bears some relationship to, and is generally greater than the input signal.

2.2 Characteristics of Measuring Instruments

2.2.1 *Nominal Range* — For each scale range, the set of values of the measurand for which a measuring instrument gives values within that scale range at a particular setting of its controls.

NOTE — The nominal range is expressed in units of the measurand regardless of the units marked on the scale, and is normally stated in terms of its lower and upper limits, for example 100 to 200°C. Where the lower limit is zero, the normal range is commonly stated solely in terms of its upper limit, for example, a nominal range of 0 bar to 100 bar is expressed as '100 bar'.

2.2.2 *Span* — The modulus of the difference between two limits of nominal range of a measuring instrument.

Example : Nominal range −5V to +5V, span 10V.

2.2.3 *Nominal Value* — A value used to designate a characteristic of a device or to give a guide to its intended use.

Example : The value marked on a standard resistor.

2.2.4 *Specified Measuring Range*

2.2.4.1 *Specified working range* — The set of value of measurand for which the error of a measuring instrument is intended to lie within specified limits.

NOTE — The upper and the lower limits of the specified measuring range are sometimes called the maximum capacity and the minimum capacity, respectively.

2.2.5 *Rated Operating Conditions* — Conditions of use giving the ranges of the measurand and of the influence quantities, and other important requirements, for which the metrological characteristics of a measuring instrument are intended to lie within the specified limits.

2.2.6 *Limiting Conditions* — The extreme conditions which a measuring instrument can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions.

NOTE — The limiting conditions for storage, transportation and operation may be different.

2.2.7 *Reference Conditions* — Conditions of use for a measuring instrument prescribed for performance testing, or to ensure valid intercomparison of the results of measurement.

NOTE — The reference conditions generally specify reference values or reference ranges for the influence quantities affecting the measuring instrument.

2.2.8 *Instrument Constant* — The coefficient by which a direct indication must be multiplied to obtain the indication of a measuring instrument.

NOTE 1 — A measuring instrument in which the direct indication is equal to the value of the measurand has an instrument constant of 1.

NOTE 2 — Multi-range measuring instruments with a single scale have several instrument constants.

2.2.9 *Response Characteristic* — For defined conditions, the relationship between stimulus and the corresponding response.

NOTE 1 — The relationship may be based on theoretical or experimental considerations, and it may be expressed in the form of an algebraical equation, a numerical table or a graph.

NOTE 2 — When the stimulus varies as a function of time, one form of the response characteristic is the transfer function.

2.2.10 *Sensitivity* — The change in the response of a measuring instrument divided by the corresponding change in the stimulus.

2.2.11 *Discrimination* — The ability of a measuring instrument to respond to small changes in the value of the stimulus.

2.2.12 *Discrimination Threshold* — The smallest change in a stimulus which produces a perceptible change in the response of a measuring instrument.

NOTE — The discrimination threshold may depend on noise (internal/external), friction, damping, inertia, quantization, etc.

2.2.13 *Resolution* (*of an Indication Device*) — A quantitative expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated.

2.2.14 *Dead Band* — The range through which a stimulus can be varied without producing a change in the response of a measuring instrument.

2.2.15 *Hysteresis* — The property of a measuring instrument whereby its response to a given stimulus depends on the sequence of the preceding stimulus.

2.2.16 *Stability* — The ability of a measuring instrument to maintain its metrological characteristics constant.

NOTE — It is usual to consider stability with respect to time.

2.2.17 *Transparency* — The ability of a measuring instrument not to affect the value of the measurand.

2.2.18 *Drift* — The slow variation with time of metrological characteristic of a measuring instrument.

2.2.19 *Response Time* — The time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within the specified limits of its final steady valve.

2.2.20 *Tracking Error* — The error arising from a lag in the response of a measuring instrument to a changing stimulus.

2.2.21 *Accuracy of a Measuring Instrument* — The ability of a measuring instrument to give indications approaching the true value of a measurand.

2.2.22 *Accuracy Class* — A class of measuring instrument which meets certain metrological requirements that are intended to keep errors within the specified limits.

NOTE — An accuracy class is usually denoted by a number of symbols adopted by convention and called the class index.

2.2.23 *Error* (*of Indication*) *of a Measuring Instrument*) — The indication of a measuring instrument minus the true value of the measurand.

2.2.24 *Limits of Error* (*of a Measuring Instrument*) — Maximum permissible errors (of a measuring instrument) or the extreme value of an error permitted by specifications, and regulations for a given measuring instrument.

2.2.25 *Intrinsic Error (of a Measuring Instrument)* — The error of a measuring instrument used under reference conditions.

2.2.26 *Bias Error (of a Measuring Instrument)* — The systematic component of the error of a measuring instrument.

2.2.27 *Repeatability Error (of a Measuring Instrument)* — The random component of the error of a measuring instrument.

2.2.28 *Repeatability (of a Measuring Instrument)* — The ability of a measuring instrument to give, under defined conditions of use, closely similar responses for repeated applications of the same stimulus.

2.2.29 *Linearity* — The closeness of the calibration curve to the specified straight line. Linearity is expressed as the maximum deviation of any calibration point on a specified straight line during the calibration cycle. It is expressed as within ± percent of the full scale value.

2.2.30 *Temperature Range, Operation* — The range of ambient temperatures given by their extremes within which the unit is intended to operate. Within this range of ambient temperature, all tolerances specified for temperature error, temperature error band, temperature gradient error, thermal zero shift and thermal sensitivity shift are applicable.

2.2.31 *Warm-Up Period* — The period of time starting with the application of power supply to the system to the time required to achieve its specified response characteristics.

2.2.32 *Ambient Conditions* — The conditions (pressure, temperature, etc) of the medium surronding the case of the signal processing module.

2.2.33 *Stability* — The ability of the system to retain its performance characteristics for a relatively long period of time expressed as within ± percent of full scale output for a period of six months.

3. SIGNAL PROCESSING DEVICES

3.1 In the field of industrial control and process control, transducers are mainly used in the centralized monitoring installations. The essential feature of centralized measurement is the conversion of all inputs into signals which can be transmitted even long distances without error.

3.2 All the devices shall operate from an ac supply 230 V (+10 percent, −5 percent), 50 Hz or from a dc source (5 to 48 V).

The following are some of the important devices:

a) Power supply,

b) Input amplifier,

c) Linearizer,

d) Output amplifier,

e) Isolation unit,

f) Functional card,

g) Automatic reference junction compensation (if provided),

h) Sensors break detector,

j) Precision integrator,

k) Square root extractor,

m) Serial data line convertors,

n) Trip amplifiers,

p) Multiplexers, and

q) Data Modems.

4. REQUIREMENTS FOR DEVICES

4.1 Power Supply — The input to the power supply is 200-240 V, 50 Hz. The voltage output may be adjustable from 5 to 48 V DC. There should be a provision for current limiting in the module. The load regulation should typically be about 0·1 percent while the line regulation should typically be 0·01 percent/V out. The temperature range for working should be 0 to 55°C. A suitable pilot light should be provided to indicate that the power supply is in ON condition.

4.2 Input Amplifier — The input amplifier should be campatible for any of the following types of inputs:

a) Platinum resistance thermometers,

b) Thermocouples,

c) Current signals,

d) Voltage signals,

e) Input from relative humidity sensors like LiCe, and psychrometric probes, and

f) Resistance tele-transmitter (potentiometer).

4.2.1 *Output* — The recommended output from the amplifier is a normalized signal for 0-1 V/0-5 V/0-10 V.

4.2.2 *Temperature Compensation* — This unit may be provided as an option on the input amplifier board.

4.2.3 *Thermocouple Failure Protection* — For thermocouple input amplifiers, this protection scheme should be incorporated for positive indication. A thermocouple failure in addition may also be indicated by a visual alarm on the panel. The sensor break optional indication should be available and it can be chosen to read either output high or output low.

4.2.4 *Temperature Drift* — A temperature drift should be minimal. Typically for V_{in} = 1 to 20 mV, the drift will be 0·4 μ V/°C and for V_{fn} = 20 mV, the drift will be of the order of 1.5 μV/°C.

4.2.5 *Interference Suppression* — This is suppressed by using an active filter of about 40 dB/decade for frequency limit of about 5 Hz.

4.3 Linearizer — The linearizer module is an important unit for thermocouple inputs, for all temperature ranges and different types of thermocouples. The output is a proportional dc current in accordance with IS : 7728-1984* or a dc voltage as specified in IS : 8493-1977†.

4.3.1 *Thermocouple Types* — J, K, R and S types of thermocouples.

4.3.2 *Logarithmic to Linear Convertor* — In some modules, a logarithmic to linear convertor may be used, for instance, in the case of electrochemical sensors, optical transducers, etc.

4.3.3 *Square Root Extractor* — This module is used for linearizing differential (pressure/flow) and can precede the integrator to give a linearized instantaneous total output.

4.4 Output Current Limit — For a voltage input to the amplifiers the output of the signal conditioning unit shall be a proportional dc current in accordance with IS : 7728-1984* or a dc voltage as specified in IS : 8493-1977†.

4.4.1 *Output Current Limit* — This is provided for probe failure, protection of down stream components and monitoring of output current without interruption of the output circuit through the internal circuitry.

4.4.2 *Response Time* — The response time may vary over a wide range typically in the range of few microseconds to milliseconds.

4.4.3 *Relay Output* — The contact rating of the relay contacts should conform to the following:

a) Maximum switching current;

b) Rated voltage;

c) Maximum switching power for a resistive load, both ac and dc; and

d) The relay switching differential shall not exceed 0·5 percent of the span.

4.5 Isolation Unit — The isolation unit is provided with a ferrite core ring or opto-isolators, etc, for decoupling input and output signal circuits.

I_{in}/I_{out} shall be as specified in IS : 7728-1984* and V_{in}/V_{out} shall be in accordance with IS : 8493-1977†.

The applications include areas for avoiding ground loops as in thermocouple, transfer to a difference reference potential or isolation from high potentials.

4.6 Precision Integrator — This gives a pulse rate output which is linearly proportional to the input signal amplitude and is amplified to drive a counter or any display.

4.6.1 *Input signals* — The signal shall be dc current in accordance with IS : 7728-1984* or a dc voltage in accordance with IS : 8493-1977†.

4.6.2 *Pulse Rate Conversion* — The output pulse rate shall be specified to convert the analogue input into exact engineering units, each pulse representing a whole or a decimal fraction of a unit.

Typical values are:

a) Minimum full scale count rate — 10 per hour, and

b) Maximum full scale count rate — 20 000 per hour.

4.6.3 *Output* — The output shall be specified whether it is open collector type or relay type with voltage and current for the load specified.

4.6.4 *Linearity* — The linearity for the integrator shall be specified, and the value given for the full span.

4.6.5 *Temperature Coefficient* — The temperature coefficient shall be specified as percent per degree Centrigrade, over a specified range of temperature.

4.7 Input Signals

4.7.1 The input signal is a dc current specified for a given value of the internal shunt, typically 0-10 mA.

4.7.2 *Outputs* — The output is a current 0-10 mA or 4-20 mA for a given value of load resistance.

4.8 Serial Data Line Convertor — These convertors used at each end of a data channel to enable serial data transmission to be established over medium distances at high speed, between devices which have RS 232 parts only or LSTTL/TTL/CMOS logic parts. It is also possible to achieve full duplex operation with hand shaking. RS 422 serial data transmission uses differential voltage reversals across a 2-wire line, the differential common mode

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rejection, with transmission rates up to 100 K Baud over distances up to 1 km.

4.8.1 *20 mA Current Loop Serial Data Transmission* — This uses current pulses of 20 mA transmit data into a reactive which may be isolated from signal ground. The quiescent loop current is a 'mark' (20 mA flowing) and '0' bits are transmitted as zero-current (space).

4.8.2 *Optional Modules*

a) Non-isolated active transmitter,

b) Isolated passive transmitter,

c) Non-isolated active receiver, and

d) Isolated passive receiver.

4.8.3 *Connection from Data Source to Transmitter (RS 232)* — Any source of serial data can be connected to the input of the transmitter as long as its two logic states are either of the following:

a) Logic inversion which can be switch selected internally, and

b) Transmissions where the ETA fail safe mode may be selected by link change.

4.8.4 *Handshaking* – The RS 232 handshake lines may be used with differential transmission exactly as per data.

4.8.5 *Power Supplies* — Each convertor must be mains powered for standard line voltage 200-250 V, 50 Hz. No power is taken from either source or distinction device. The convertor should be connected to the same main supply as the device which it serves.

4.9 Trip Amplifiers — The trip amplifiers may be of any of the following types:

a) General purpose single trip amplifier;

b) General purpose dual trip amplifier; or

c) Low signal level, mV and thermocouple input single and dual trip amplifier.

4.9.1 *Input Signals* — The input signals may be dc current (mV) with internal shunt value specified, or dc voltage (mV) with maximum and minimum input spans specified, or resistance charge. For potentometric inputs, the type of systems whether two, three or four types of system and whether two, three or four wire must be specified. For platinum resistance thermometers, the value of the resistance at 0°C and the temperature span should be specified including the type of connection whether two, three or four wire type. For thermocouples, automatic cold junction compensation may be provided and broken thermocouple protection must be incorporated.

4.9.2 *Low Level Signals* — For low level signal application, it is better to convert the dc signal into an ac signal by suitable techniques to reduce noise interferences.

4.9.3 *Relay Output* — The number of relay contacts provided must also be specified with maximum switching current rated voltage, switching power for ac/dc resistive loads (*see* **4.4.3**).

4.9.4 *Set Point Dials* — These can be of many types including the following types:

a) Ten turn digital dial potentiometer,

b) Screw driven adjustment type,

c) Thumbwheel switch type, and

d) Push button input type.

4.9.5 *Power Supply* — The power supply will be from 230 V, 50 Hz, with normal permissible variations.

5. TESTS

5.1 Test Conditions — Unless otherwise agreed or otherwise specified below, the tests shall be carried out under the following conditions:

a) Normal mounting position,

b) Temperature: 27 ± 2°C,

c) Relative humidity: Not exceeding 60 percent, and

d) Nominal power supply voltage and frequency.

5.2 Routine Tests

5.2.1 *General Tests*

5.2.1.1 *Insulation level*

a) The insulation resistance of the equipment shall be determined by applying 500 V dc between each terminal in turn and earth and shall have an insulation resistance of not less than 20 megohms.

b) The equipment shall withstand the application of 1·5 kV rms at 50 Hz for 1 minute, applied between each supply terminal in turn and earth. For equipment rated below 100 V, the test voltage shall be 500 V rms.

5.3 Type Test — The following type tests shall be carried out on at least one equipment of each type.

5.3.1 *Interference Rejection* — These tests involve the series mode and common mode types. For series mode, an interfering signal of 1 V rms at mains frequency is applied from a source having an output impedance of 30 ohms. For common mode, with and without the application of an interfering signal of 100 V rms at mains frequency between the input and earth, the test shall be carried out.

5.3.2 *Power Supply Variation* — The equipment shall respond correctly when tested as specified with supply voltages 10 percent above and 20 percent below the reference conditions, at frequencies 1 Hz above and 2 Hz below the nominal value.

For dc supply, the test shall employ a 50 Hz ripple of 1·4 V peak to peak for 48 V supplies and 0·7 V peak to peak for 24 V supplies.

5.3.3 *Power Supply Transient Over Voltage* — With the equipment operating, transient over voltages of the following amplitudes and durations shall be superimposed on the nominal supply voltage. The equipment shall respond correctly.

Peak-Over-Voltage (Percent of dc or rms of Nominal Supply)	*Pulse Duration*, mS
100	10
200	1
300	0·02
500	0·005

5.3.4 *Magnetic Flux Density* — Response tests shall be carried out with the equipment subjected to a magnetic flux density of 0·5 mT and the equipment shall respond correctly.

5.3.5 *Climatic Tests*

5.3.5.1 *Dry heat/dry cold* — These tests shall be carried out in accordance with the procedures laid down in IS : 9000 (Part 1)-1981*. The instrument shall perform satisfactorily after the completion of test.

5.3.5.2 *Damp heat cycle completion of the test* — This test shall be made in accordance with IS : 9000 (Part 3)-1981† and the instrument shall perform satisfactorily after the completion of the test.

5.3.6 *Dynamic Tests* — When subjected to the tests, the equipment shall be fully assembled into its major units.

5.3.6.1 *Vibration* — This test shall be made as specified in IS : 9000 (Part 8)-1981‡. A reasonance search shall be carried out over the range 15 to 150 Hz at an acceleration of 5 m/s^2 at a rate not exceeding 1 octave per minute, the test being made in three mutually perpendicular planes. Major frequencies shall be reccorded and an endurance test of 6 hours duration shall be carried out at each of these frequencies. No failure shall occur.

5.3.7 *Radio Frequency Interference Test* — Under consideration.

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*Specification for basis environmental testing procedures for electronic and electrical items: Part 1 General.

†Specification for basic environmental testing procedures for electronic and electrical items: Part 3 Dry heat test.

‡Specification for basic environmental testing procedures for electronic and electrical items: Part 8 Vibration.

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